Energy Recyclers

ISO9001

Reinversion Discharger
Energy Recycler Series
2 kW - 102 kW DC capable

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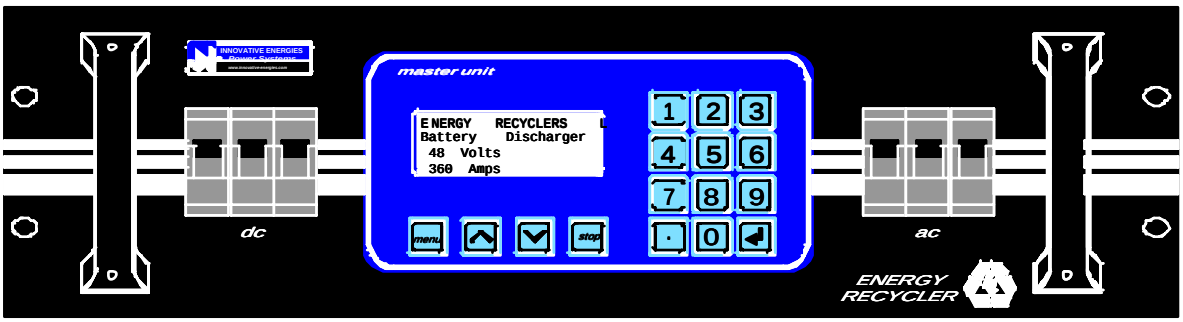
Reinversion Discharger

User's Manual



Energy Recyclers Ltd.

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Contents

Section	*Page*
Introduction	3 - 5
❖ About the Energy Recycler products	3
❖ Definition of Terms	3
❖ System Elements	4
❖ General Overview	5
Theory of Operation	6 - 7
❖ Block Diagram	6
❖ Description	7
Installation Instructions	8 - 10
❖ AC Mains Connection	8 - 9
❖ DC Connection	9
❖ Serial Communications Connection	9
❖ Physical Installation	10
Functions and Features	11 - 13
❖ Discharger Functions	11
❖ Status and Fault Messages - Unit	11 - 12
❖ Status and Fault Messages - System	12
❖ Master / Slave Functions	13
Product Specification	14 - 15
Operating Instructions	16 - 23
❖ Menu State Diagram	16
❖ Getting Started	17
❖ Menu Operating Instructions	18 - 23
❖ Thermal De-Rating	24
Appendices	
❖ Master Unit Keypad and Display	25
❖ Typical System Configuration	26
❖ Front / Rear Panel Layouts	27
❖ Wiring Connection Diagram	28
❖ Rating Label	28
❖ Model Selection Table	29
❖ Safety Notice	29
❖ Menu State Diagram (for quick reference)	30

Introduction

About the "Energy Recycler" products

The reinversion discharger product line is a revolutionary product from the "Energy Recycler" family of products. It enables precise, controlled and monitored discharge of battery banks in telecommunications, utility, UPS and other applications.

Traditional methods of discharge testing involve at best crude control of the discharge rate, and convert the considerable amounts of energy from the battery into heat which is problematic to dissipate, and in many installations there is a risk of overheating other equip ment.

The reinversion discharger instead converts the DC energy from the battery not into heat but usable AC energy which is fed back into the incoming AC mains supply. This energy can then be used in the installation premises to offset electricity costs, or if the installation consumes less electricity than that generated by the reinversion discharger, the user will have a net gain and the energy will flow into the distribution system. Comprehensive interlocks and protection systems provide foolproof protection and safety.

The Reinversion discharger consists of a 19-inch rack case that can house either one, two, or three 2 kW inverter power modules. Each module can individually synchronise to its own mains source and hence the user can decide on single, dual or triple phase connection (assuming sufficient inverter power modules).

To increase the discharge capability beyond the 6 kW limit of a single discharger unit extra 6 kW Slave Units can be controlled by the Master discharge unit.

Initially a 48v version of the Reinversion discharger has been developed, but it is the intention that 24v, & 110v versions will also be developed, as well as other possible intermediate voltages.

Definition of Terms

The following should help clarify the terminology used throughout this document:

- *System* – A number of dischargers connected together via an RS-485 interface to discharge a common set of batteries. A minimum system would be a single Master discharger and a maximum system would be a Master discharger controlling 16 Slave dischargers.
- *Unit* – A generic name given to a discharger irrespective of whether it is a Master or Slave Unit. A Master Unit can have a discharge capacity of either 2, 4, or 6 kW.
- *Module* – A name given to the internal 2 kW inverter power module that makes up a unit. Note that a unit can have 1, 2, or 3 inverter power modules.

System Elements

Units

A reinversion discharger system can have a maximum power discharge capacity of 102 kW. The units making up a system are as follows:

1. Master Unit: One (1) only Master Unit is used in a single system. For user interface the Master features a Liquid Crystal Display together with a keyboard for user input of parameters and control of the system. Three different versions are available: 2 kW, 4 kW and 6 kW and these incorporate one, two or three 2 kW power conversion modules respectively. 2 kW units can operate into single phase AC supply only, 4 kW units can operate into single or two phase AC supply, and 6 kW units can be operated into one, two or three phases dependent on how the us er connects to the supply.
2. Slave Unit: Up to Sixteen (16) Slave Units rated 6kW can be used in a single system, operating in parallel with the Master Unit. As with Master Units, Slave Units can be operated into one, two or three phases dependent on how the user connects to the supply. The Slave Unit features a hexadecimal address select switch on the front panel which must be set to a unique address in the system. Together with the Slave address switch are 3 LED' s:
   i. Power Green LED
   ii. Data Yellow LED
   iii.Fault Red LED

Master Unit Front Panel, Keyboard and Display

The Master Unit front panel incorporates DC and AC miniature circuit breakers (MCBs). Depending on the capacity of the Master Unit there will be one, two or three each of DC and AC MCBs. This corresponds to 2 kW , 4 kW and 6 kW types respectively.

The display is a back lit Liquid Cry stal Display (LCD) of 4 lines x 20 characters.

The Keyboard consists of a numeric keypad incorporating digits 0 through 9, decimal point, and Enter (5). In addition, 4 separate keys allow Menu and parameter selection, and STOP :

"Menu" key allows access to Menu selection

"Up" key permits navigation between some screens and fields

"Down" key permits navigation between some screens and fields

"STOP" key allows the user to interrupt a discharge test immediately at any time (forcing the system into Standby Mode), and overriding the system 'Discharge Terminate' parameters.

Operating Concept

The System is operated using the keyboard and display to select parameters, monitor status, display error messages and other functions.

The display is Menu based, and incorporates menu screens, display screens, and setup screens. For an overview of the structure see Figure 1.

General Overview

The reinversion battery dischargers were designed to achieve a clear goal. This particular objective was to provide an accurate, controlled and heatless alternative to traditional battery discharge techniques. A simple resistive battery discharge test load has many drawbacks, and they are:

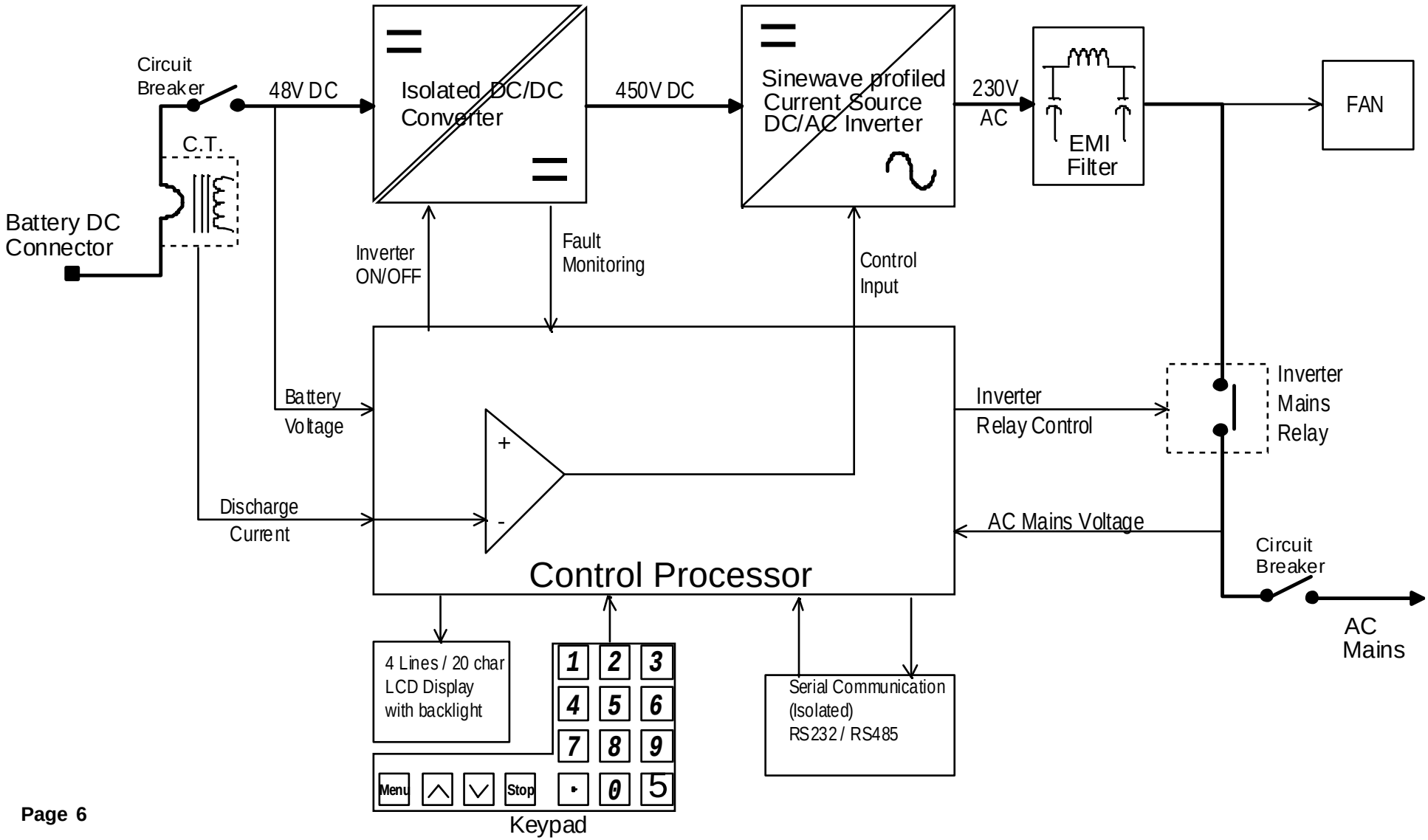
1. Resistance value needs to be continuously adjusted throughout the discharge to achieve a constant discharge current.
2. Requires full time monitoring by a technician to record battery terminal voltage, time and manually calculate Ampere-hours.
3. Relies entirely on the technician to terminate the test once the terminal test voltage has been reached.
4. Energy from the batteries is dissipated as heat, which consequently increase the ambient temperature of the test area (usually the battery room).
5. Bulky, cumbersome units.

The Reinversion discharger overcomes these problems by proving a compact and complete test unit that allows the user to enter any desired discharge current from 5% to 100% of the maximum rating of the unit. Then it continually adjusts the load presented to the battery to achieve this discharge current while monitoring both the battery terminal voltage and actual discharge current.

A low battery voltage cut–out ensures that the batteries will not be over discharged. The energy from the battery packs is fed into the AC mains to ensure absolute minimal heat is generated in the battery room while testing the condition of each battery.

The system is set up to allow the control from a front panel keypad while providing a feedback of battery voltage, charge and discharge currents and any other status information via an LCD display.
In future it is planned that the system will be able to perform all control and monitoring remotely via the use of the RS-232 / RS-485 serial communication ports.

Reinversion Discharger Block Diagram



Theory of Operation (refer Block Diagram)

While in discharge mode, the unit converts the low voltage DC power from the batteries into a high voltage AC power source that matches the present mains supply voltage and frequency, and this enables a transfer of power into the mains "supply". By doing this, the energy from the batteries is transferred into the mains "supply" and only a small amount of the dissipated battery energy is dispersed in the form of heat due to certain inefficiencies. This conversion of the low DC battery voltage to mains voltage AC is a two stage process, best described by the following two points.

DC > DC Converter

The first stage consists of an isolated DC –> DC converter. This steps the battery voltage up to a nominal 450V DC and provides safety isolation of the batteries from the potentially lethal mains supply.

DC > AC Inverter

The second stage comprises of a current mode profiling inverter stage that monitors the present mains supply and profiles the 450V DC into a sinewave AC voltage in step with the mains. By being current mode the inverter can profile the mains current to be sinusoidal resulting in an extremely low Total Harmonic Distortion of the power that is fed into the mains.

Mains Filter

The purpose of the Mains Filter is to eliminate any Electromagnetic Interference generated by the inverter getting into the mains.

Mains Isolator

This ensures that the inverter module is disconnected from the mains when a discharge cycle is not being performed.

Cooling Fan

The purpose of the fan is to keep the temperature of every component inside the discharger well within the recommended safety margins by the manufacturers. As such, it only operates when the unit is in the discharge mode.

Control Processor

The control processor provides the user interface via the keypad and display, controls and monitors the status of the power modules, and communicates with other dischargers (if any) in the system. The serial communication interface is completely isolated.

Control Strategy

The Current Transducer is monitored to determine actual discharge current and compared the set current, resulting in continual adjustment of the inverter stage to present the batteries with a constant current.

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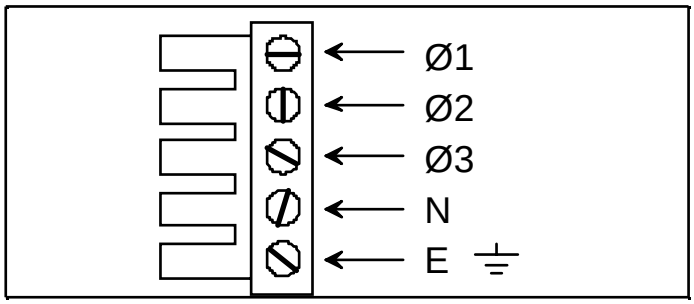
Installation

AC Mains Connection

All units are fitted with a 5 way AC Mains connector on the rear panel; observe the diagram below for correct connection to the cable socket supplied:

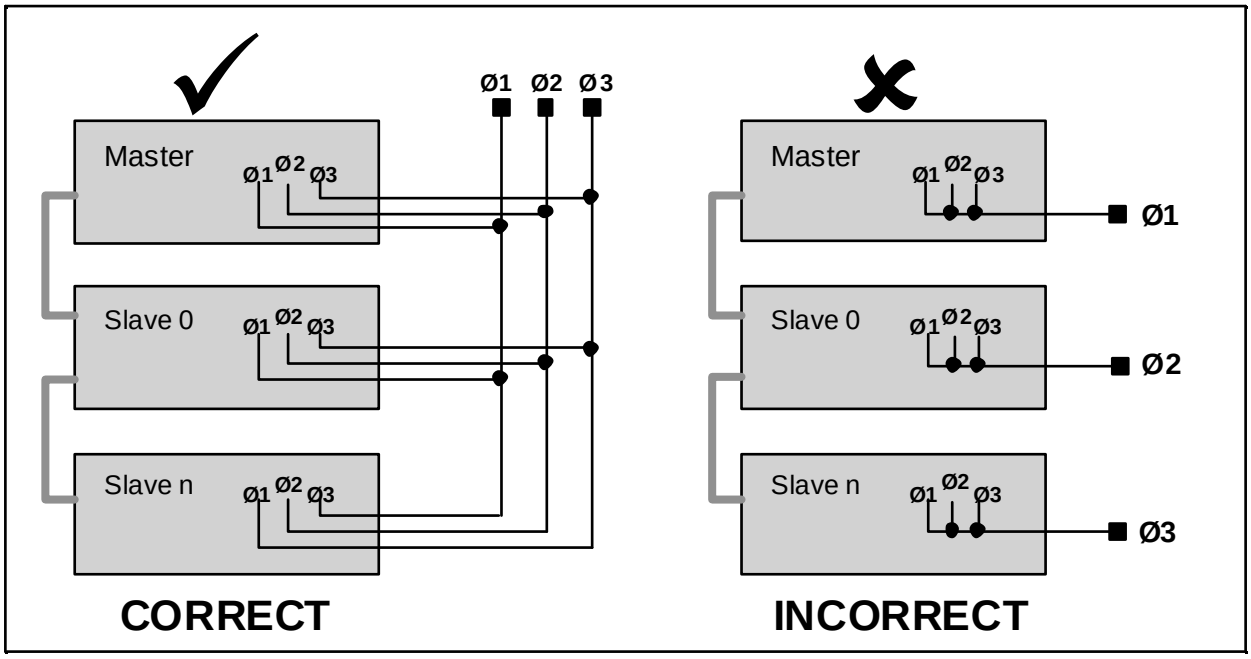


- On 2kW units, single phase Ø1 - Neutral - Earth is the only valid connection
- On 4kW versions, connect Ø1 and Ø2 plus Neutral and Earth. Ø1 and Ø2 can be connected to either one common phase, or two separate phases.
- On 6kW versions, connect Ø1, Ø2 and Ø3 plus Neutral and Earth. Ø1 / Ø2 and Ø3 can be connected to one, two or three phases.

Notes:

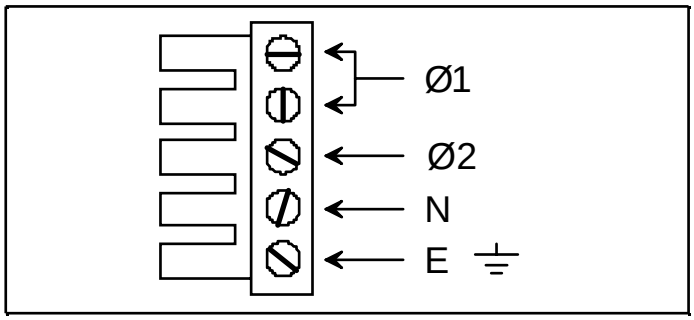
1. Neutral and Earth connections are essential, regardless of connection method used.
2. Menu [9] Mains Configuration must be set to the correct number of phases:
   i. 1Ø- set # phases = **1**
   ii. 2Ø- set # phases = **2**
   iii.3Ø - set # phases = **3**
3. Rated AC Voltage displayed is Line to Neutral Voltage. (MENU [4] and MENU [9]).
4. Although 3Ø units can be connected to just one single phase supply, it is recommended that connection to 3 Ø be used if possible (see below).
5. The Phase connection order is *not* critical, e.g. Ø1, Ø2, Ø3 can be connected in any order to the mains red, yellow and blue phases.

Connecting Multiple (6kW) Units to 3 Ø:



Installation (cont.)

Connecting a 6kW Master or Slave Unit to 2 Ø supply:



Connect first phase to terminals 1 Ø and 2Ø
Connect second phase to terminal 3 Ø
Note: *this is the only valid 2 Ø connection*

DC Connection

When connecting any unit to the batteries, observe care in ensuring that the correct sequience is observed.

1. With the 'Anderson' DC plug disconnected from the discharger, connect the DC wires (user supplied) to the batteries. **IT IS MOST IMPORTANT THAT CORRECT POLARITY IS OBSERVED: DAMAGE TO THE DISCHARGER WILL RESULT FROM REVERSE POLARITY CONNECTION.**
2. With all DC circuit breakers (MCBs) turned OFF, plug the Anderson DC connector into the discharger.
3. Turn on DC circuit breakers.

Notes:

1. When a DC circuit breaker is closed an audible "splat" sound is heard due to the inrush current into the discharger. This is normal and is not harmful to the discharger.
2. Whilst performing a discharge test on a battery it should be isolated (fully disconnected) from the charger / rectifier and any other loads or equipment that are normally connect ed.

Master / Slave DC connection

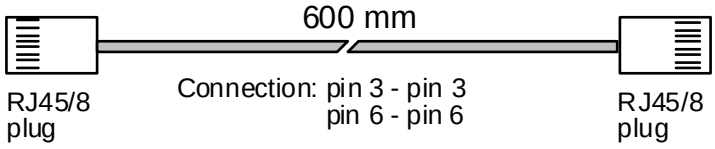
See *Wiring Connection Diagram* , page 28

System Serial communications (RS-485) connection

See *Wiring Connection Diagram* , page 28

Note: both ends of the serial cable have the same plug (RJ45) and can be connected either way around to achieve 'daisy chain' connection of the communications bus. Similarly, of the two RJ45 sockets at the rear of each unit, connecting to either socket is valid.

RS-485 cable:



Physical Installation

All units are designed for standard IEC 19" equipment racks of at least 500mm depth. For ease of use 600mm depth is recommended.

It is essential that the ventilator module supplied is installed directly below each discharger. This enables the free passage of cooling air into the front underside of the discharger unit, and the exit of heated air at the top rear of the discharger unit.

It is important to observe the following at time of installation:

1. If any unit is installed at the top of a rack, at least 1RU free space should be provided above.
2. The top vents at the rear of the discharger must be clear and free of obstructions.
3. The back of the equipment rack must be open
4. The discharger units are designed for permanent installation.
5. The rear of the discharger must be supported: a an M6 tapped hole is provided in the back panel of the discharger for this purpose. A support bracket (user supplied) should be fitted.

Setting of Slave Address

Slave addresses must be unique and set prior to powering up the equipment. The address is set by the hexadecimal rotary switch on the front panel of the Slave Unit, which allows a maximum of 16 individual addresses from 0 through F. In any system the frst Slave Unit must be set to address 0, the subsequent unit(s) to consecutive addresses.

System Redundancy

In the event that a power module fails, the user can by use of the Master Unit MENU [6] determine which module has failed. By turning OFF the associated DC circuit breaker, the system can continue to be operated at a lower output power (reduced by 2kW per module)
Each power module can be tested in turn by simply enabling one power module at a time and initiating a discharge test using just that single module
With the complete system running, MENU [6] allows the monitoring of the status of any individual power module.

Discharger Functions and Features

The discharger has some functions that have been specifically designed for the function of battery discharge testing. When a discharge test is initiated the display shows the following information:

- ***Discharge Current*** – User selectable through the numeric keypad.
- ***Battery Voltage*** – An indication of the battery terminal voltage.
- ***Discharge Time*** – An indication of the accumulated duration of the discharge test.
- ***Discharge A Hr*** – An indication of the accumulated amp-hours (Ahr) discharged during the duration of the test.
- ***Fault Status*** – An indication of the current status of the discharger and any faults that have occurred.

If a discharge test is terminated for any reason (user or discharger terminated) the timer and the A Hr accumulator will stop while maintaining their current values, also the final battery voltage and current will be recorded. If a new discharge test is initiated the timer and Ahr accumulator will carry on from their current values. At any time the user can reset both the discharge timer and Ahr accumulator.

Before a discharge test the user can preset some parameters for the discharge test:

- ***Minimum Discharge Voltage*** – The minimum voltage that the batteries will be discharged down to.
- ***Maximum Discharge Time*** – The maximum duration of the discharge test.
- ***Maximum Discharge Ahr*** – The maximum amp-hours that will be discharged out of the batteries.

Note: Any or all of these parameters may be set to zero, which effectively disables any parameter (each parameter can be individually turned off so that it will not be able to terminate the test).

The first parameter to be met during the discharge test will terminate the test. The parameter that caused the termination of the test will be flashing on the display as well the status message "Discharge Finished" and the buzzer will sound continuously until the first key-press, alerting the user to the reason for the termination of the test. The discharger will display the final values for the discharge timer, Ahr accumulator, final battery voltage, and discharge current.

Discharger Status and Fault Messages - Unit

Apart from the discharge related information, the discharger display is able to indicate the current status of the discharger along with any fault messages:

- ***Discharge OK*** – The discharger is functioning normally and discharging the battery.
- ***Standby*** – The discharger is in a standby mode awaiting a user input of discharge current.
- ***Initialising*** – The discharger is responding to a user input of discharge current and the discharger is going through its initialisation process.
- ***Low Battery Voltage*** – The battery voltage is to a point that would cause damage to the batteries if discharged any further (independent to user selectable minimum discharge voltage).
- ***High Battery Voltage*** – The battery voltage is to a point that would cause damage to the discharger if a discharge was enabled (e.g. a 24V discharger on a 48V battery).

Discharger Status and Fault Messages - Unit cont.

- ***Over Temperature*** – The discharger internal temperature cutout has been activated. This can be due to the discharger operating at higher output power than specified for the ambient temperature (see thermal de-rating chart on page 24), or the discharger ventilation holes may be obscured.
- ***Mains Fault*** – The AC mains supply is out of specification i.e. the voltage is either too high or too low or alternatively the frequency is either too high or too low. As with all Re-Inverters the inverter and user need protecting from the consequence of operation without a mains reference (disconnection from the mains supply) this is normally referred to as "island protection". This discharger utilises island protection; partial disconnection from the mains (e.g. one of three phases) will result in a mains fault message and the discharger stopping. Total disconnection from the mains reference will result in the discharger totally shutting down.
- ***Current Limited*** – The discharger is unable to achieve the entered discharge rate. During this condition the discharger will display the actual discharge current and continue to discharge the battery. This condition should only occur if the battery voltage is extremely low or momentarily if a mains glitch occurs.
- ***Over Current*** – The internal over current fail safe circuitry has been tripped.

All fault conditions (except initialising and current limited) will stop the offending power module from operating, leaving the other power modules in a discharger unit to carry on. All fault conditions are announced by short repetitive "beeps" from the buzzer.

Discharger Status and Fault Messages - System

A system consists of a master discharger and at least one slave discharger. The Master Unit will display not only its own fault messages but also the fault messages of all of its slaves. Only one fault message will be displayed at a time, and the user will have to look at all the slave fault LEDs in order to determine which unit has caused the fault. The "Discharging OK" message will only be displayed if the master and all of its slaves are discharging OK.

As well as the unit faults listed above there are some specific system status / fault messages that pertain to a system:

- ***Discharge Finished*** – If the discharge has been terminated due to either the maximum discharger Ahr limit, maximum discharge time limit, or minimum discharge DC voltage limit being met then the "Discharge Finished" status message will be displayed.
- ***Communications Fault*** – This message is displayed if the master discharger detects that a Slave Unit has an incorrect address switch setting (this causes bus contention on the RS-485 serial interface).
- ***Slave Compatibility*** – If the master discharger finds that its connected slaves are not compatible it will display this message.

Master / Slave Functions

A master discharger unit features a 16-key numeric keypad and a 4-line by 20-character LCD display. A slave discharger unit does not have a keypad or a display but instead features three status LED's and a 16-position rotary HEX switch for setting the slave address. All dischargers feature an RS-485 serial communications port. A master discharger also features an RS-232 port which in future will allow communication between a master discharger unit and a personal computer (PC), where as the RS-485 port allows communication from a Master discharger unit to any number (Up to 16) slave discharger units.

Slave discharge units are connected to a master discharger unit by simply connecting an RS-485 cable between the units (in a "daisy chain" fashion) and connecting the DC battery inputs to each discharger across the same bank of batteries in a parallel fashion (series and series-parallel connections will be allowed in the future).

Once a number of Slave Units have been connected to a master discharge unit the control of all of the dischargers is possible through the keypad and display of the Master Unit. The master discharge unit acts as if it where a single discharger with a discharge capacity equal to the total of itself and all of its connected Slave Units. The extra discharge capacity of the Slave Units is integrated into the Master Unit in a way that is totally seamless to the user.

For example, if a 48V / 120A Master Unit has another 48V / 120A Slave Unit connected to it in a parallel connection, the Slave Unit would display that it is actually a 48V / 240A discharger. The user can then enter any discharge current from 5% to 100% of this 240A total capacity. The displayed discharge current, Ahr accumulator total, discharger status and fault messages take into consideration the total combined effect of the master and its connected Slave Units. A series connection of the above mentioned two 48V / 120A dischargers would result in the Master Unit displaying it was a 96V / 120A discharger.

Each slave discharger unit in a system must be assigned its own unique address (0 –F HEX), by setting the front panel rotary switch, and these must be assigned consecutively starting at 0.

A master discharger unit can be used to interrogate any of its slaves and display appropriate information about the slave on its display (e.g. check a slave's rating or serial number). The master discharger is also able to inform the user to the total number of Slave Units connected to it.

Specifications

Electrical :

DC Input Voltage :		24 / 48 / 110V nominal
Low Battery Voltage Disable :		18 / 36 / 82V
High Battery Voltage Disable :		29 / 57 / 131V
Discharge Power :		2kW / 4kW / 6kW @ 20°C
Discharge Current :		5% to 100% of rated current
DC Input Voltage Ripple :		< 1%
AC Mains Voltage :		220 / 230 / 240V ±20%. (specify when ordering)
AC Mains Current :		+0.2A to -8A / phase(220-240V)
AC Mains frequency :		50 / 60Hz nominal ±10%. (specify when ordering)
Efficiency :		90% typ.
EMI /RFI:		to CISPR22 / EN60522 level A
AC Current Draw / Supply :		Sinusoidal <5% THD, to IEC1000-3-2, IEC555, EN6100 0-3-2, JEAG9701
Converter Operating Frequency:		first stage 54kHz, second stage variable 15kHz to 100kHz
Safety :		to IEC950, EN60950, AS/NZS3260
"Island Protection ":		±10% on mains frequency ±20% on mains voltage
Isolation:	AC Mains to case	3500VAC 1 min
	DC to case	1kV (with DC bypass capacitor removed)
AC Mains Circuit Breaker :		220-240V 10A
DC Circuit Breakers :		24V 60A
		48V 40A
		110V 20A

Accuracy:

Discharge Current :	±2.5% of full scale
DC Voltage/Current Monitoring :	±1.0% of full scale
AC Voltage Monitoring :	±2.0% of full scale
AC Frequency monitoring :	±1.0% of full scale
Ampere-Hour monitoring :	±2.0% of reading
Time elapsed :	± 1 second

Physical:

Ambient Humidity:	0-95% RH non-condensing
Ambient Templerature :	-10°C to +40°C fan cooled (also refer thermal de-rating page 24)
Weight (unpacked) :	2kW 17kg, 4kW 23kg, 6kW 29kg
Weight (packed) :	2kW 23kg, 4kW 29kg, 6kW 35kg
Weight of accessories :	Ventilator, Manual, cables and plugs 650g

Size :	483W x 134H x 500D (mm)
DC Battery Connection :	Grey 175A 2 pole Anderson connector
AC Mains Connection :	5 way "Phoenix Power Combicon" connector
Orientation :	Normal vertical 19" equipment rack mount

(**note** that 1RU ventilator module must be intalled underneath unit and that top rear vent must be free of any obstruction at all times).

RS-232 / RS-485 Serial Communications Interface

RS-232 : for Personal Computer (PC) connection . Isolated to 1kV

RS-485 : for Slave Unit control, allows full control and monitoring of Slave Units from a Master Unit. Isolated to 1kV.

Control Interface:

Master Unit

16 button keypad
4 line x 20 character backlit LCD display
Buzzer to annunciate end of discharge or fault.
These items provide full user interface to the system including Slave Units

Slave Unit

Primary control is achieved via the RS-485 serial interface
16 position hexadecimal rotary switch (Address selection)

LEDs	Power ON	Green
	Data	Yellow
	Fault	Red

Buzzer to annunciate a fault condition.

Accessories:

Master Unit

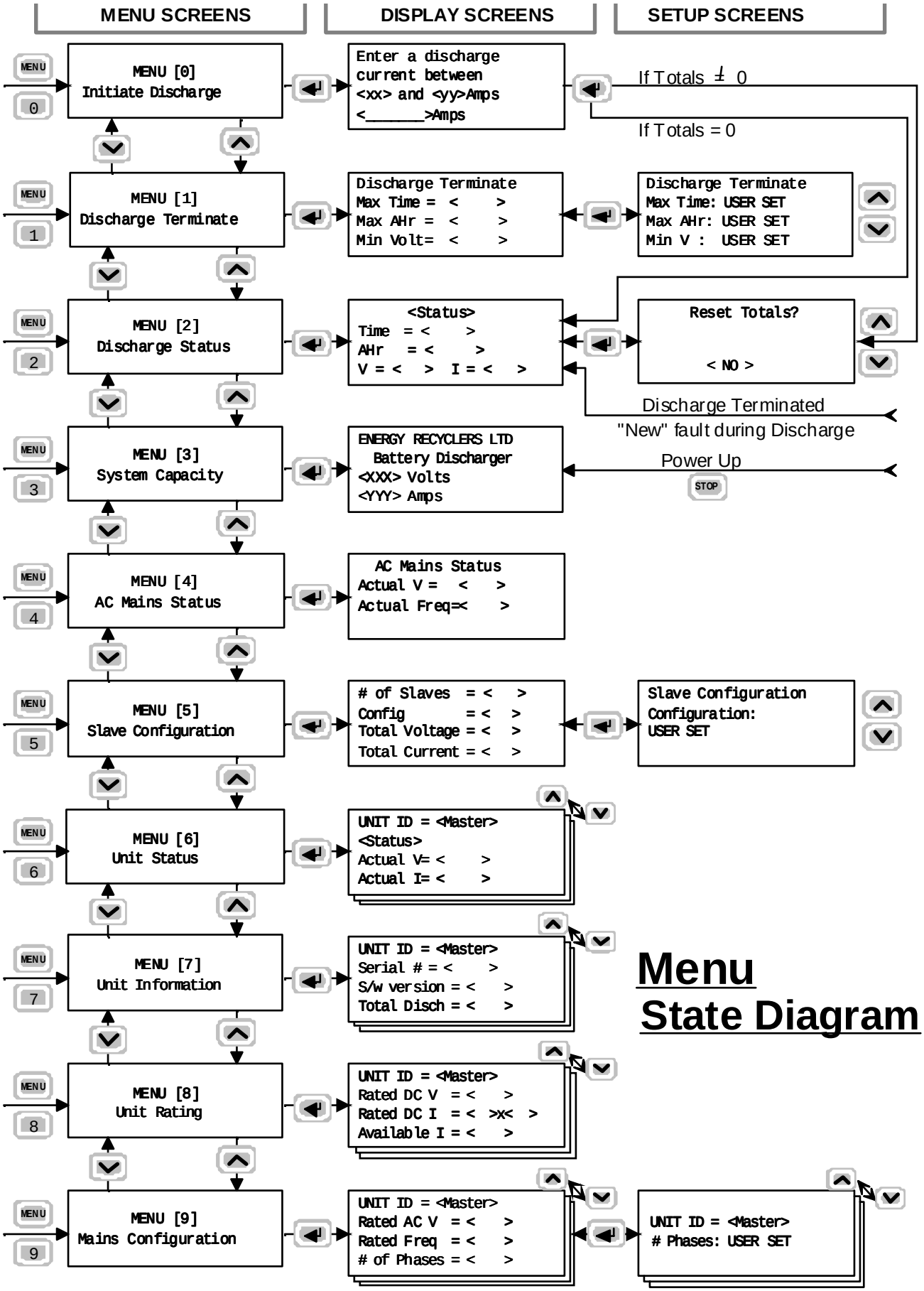
i. 175A DC "Anderson" mating connector
ii. Ventilator module - 1RU x 19", to be fitted underneath
iii. 5 way "Phoenix" cord mounted AC mains connector
iv. 2 metre RS-232 serial cable DB9F > DB9M (PC connect)
v. Users Manual

Slave Unit

i. 175A DC "Anderson" mating connector
ii. Ventilator module - 1RU x 19", to be fitted underneath
iii. 5 way "Phoenix" cord mounted AC mains connector
iv. RS485 serial cable RJ45>RJ45 600mm long

175A DC Anderson Connector Colours

(Note - Different colour connectors will not key with each other!)
24V DC - Red
48V DC - Grey
110V DC - Blue



Menu State Diagram

Operation

Getting Started

Refer to State Diagram on previous page for reference to the following discussion

Initial Power On, Power On Display

When all connections to DC battery and AC mains supply have been made and checked, the user can power up the system Master Unit and Slave Units (if any) by closing all MCBs.

The following is displayed:

```
ENERGY RECYCLERS LTD
 Battery Discharger
<xxx> Volts
<yyy> Amps
```

Power On Display above shows the total *System* capacity as follows:

- **Volts**: the *System Voltage* which must match the nominal battery voltage which is to be discharged
- **Amps**: the total *System Current* capacity (i.e. the maximum discharge capacity of the system). This is generated dynamically at power up when the Master Unit detects and interrogates all Slave Units (if any) connected to the Master Unit.

Example: if a 6 kW Master Unit is connected with two Slave Units, total system capacity is 18 kW. For 48V nominal battery system the display will be as follows:

```
ENERGY RECYCLERS LTD
  Battery Discharger
048 Volts
0360 Amps
```

Operating the Discharger

At initial power on, the user can press the [Menu] key then a number corresponding to the menu required - for example [Menu] [4]. Alternatively, the user can press the [Menu] key then the [Up] or [Down] keys to display the required menu.

When the desired menu is displayed, press the [Enter] key to select the menu options.

Menu [0] Initiate Discharge

```
Enter a discharge
current between
<xx> and <yy> Amps
<_______> Amps
```

The master display dynamically indicates the minimum and maximum discharge values dependent on the total available discharge of the system (master and its associated Slave Units). Turning a DC breaker off on a slave or the master will reduce these values, thus intermediate or finer resolution discharge values may be entered:

- with only one DC circuit breaker turned on, a discharge current between 5% and 100% of a single module current rating can be entered. For example, 48V from 2A to 40A.
- with two or more DC circuit breakers turned on, a discharge current between 50% and 100% of the enabled system discharge capacity can be entered. For example, a 48V system with two DC circuit breakers turned on discharge from 40 to 80A can be entered, and with six DC circuit breakers turned on a discharge from 120A to 240A can be entered.

Enter the desired discharge current using the numeric keys, then press the [Enter] key to initiate a discharge. If totals are not equal to zero then the display will prompt the user as to whether the values should be reset back to zero. Pressing [Enter] will NOT reset the current totals to zero, and the discharge will be initiated. Pressing [0] [Enter] WILL reset the current totals to zero, and the discharge will be initiated.

Notes:

1. in the unlikely event that a power module fails, the system can be operated at less power by first isolating the faulty module by turning off its respective DC circuit breaker.
2. for an explanation of totals see Menu [2].

Menu [1] Discharge Terminate

```
Discharge Terminate
Max Time =  off
Max A Hr =  off
Min Volt =  off
```

This menu displays the maximum and minimum limit parameters that have been set for a discharge test. During testing, immediately that the first of these parameters is met the discharge will be terminated.

Menu [1] cont.

Pressing the [Enter] key when in the "display screen" will switch to the "setup screen":

```
Discharge Terminate
Max Time: 00:00
Max A Hr: 0000
Min Volt: 000.0
```

In the "setup screen" the user can use the [Up] or [Down] keys to change between the different fields. Values for max. time, max. Ahr, and min V can be entered using the numeric keypad to enter the value, followed by the [Enter] key. Entering a value of zero for any field turns the field off, resulting in the word "off" being displayed for that field when the setup screen is exited. Entering values for the minimum voltage field above or below pre-allowed limits cause rounding up or down to the appropriate limit.

The Max. Time field is entered in hours and minutes (note that during and after discharge the display will show hours / minutes / seconds).

Menu [2] Discharge Status

```
    <Status>
Time  = <      >
A Hr  = <      >
V = <    > I = <    >
```

This screen is switched to whenever a discharge is started or terminated, or if a "new" fault occurs during a discharge. The first line shows the status of the system, which will be one of the following messages:

Status Messages	Fault Messages
Standby	Current Limited
Initialising	Low Battery Voltage
Discharging OK	High Battery Voltage
Discharge Finished *	Over Temperature
	Over Current
	Mains Fault
	Communications Fault *
	Slave Compatibility *
* *System Status / Fault Messages* (not Unit Status / Fault messages)	

If the status message is either "Standby" or "Discharge Finished" the following three lines of the "display screen" indicate the final results from the last test otherwise the following three lines of the "display screen" show the results of the current discharge test.

Time is displayed as hours : minutes : seconds.

Menu [2] cont.

Pressing the [Enter] key when the "display screen" is showing will switch to the "setup screen", here the user is prompted as to whether they want to reset the totals. The default setting is <NO>. Pressing the [Enter] key will exit the "setup screen" without resetting the totals, where as pressing the UP or DOWN keys will toggle between <YES> and <NO>. Display <YES> followed by the [Enter] key will reset the totals.

If the test has been terminated due to the preset maximum time, maximum Ahr, or minimum voltage being met the status line will display the words "Discharge Finished" and the reason for the discharge being terminated i.e. the label "Time =", "Ahr =", or "V =" will be flashing (but the number associated with the label is constantly on).

Note the value stored in the field "discharge current" when a discharge has been terminated is the last user "set current" value (not the final discharge actual current value).

Menu [3] System Capacity

```
ENERGY RECYCLERS LTD
  Battery Discharger
<XXX> Volts
<YYY> Amps
```

This is the same initial screen that is displayed at first power up until the [Menu] key is pressed. This screen is also displayed when the [Stop] key is pressed. This screen displays the rating for the discharger based on the rating of the master and all slaves connected to it: i.e. the total system capacity. This rating does not take into consideration the fact that some units may have a reduced capacity due to DC circuit breakers being turned off. I.E. this is the total maximum possible capacity of the discharger system: Master Unit + Slave Unit(s).

Menu [4] AC Mains Status

```
AC Mains Status
Actual V    = <     >
Actual Freq = <     >
```

This display screen simply shows the current AC mains voltage and frequency.

Menu [5] Slave Configuration

```
# of Slaves  = <    >
Config         = <    >
Total Voltage= <    >
Total Current= <    >
```

The "# of slaves" field displays the number of slaves found by the Master Unit.

The "Total V" and "Total I" fields display the total rating of the system based on the rating of the master and the slaves connected, and the "configuration" field value. The "Total V" and "Total I" fields are the same as that which is displayed in the "display screen" of Menu [3] - System Capacity.

Note that in future it is intended that the software will be enhanced to enable the user to change the "Configuration" field by pressing the [Enter] key to switch to the "setup screen", then the [Up] and [Down] keys will enable the selection of various options: Parallel, Series 2, Series 3, or Series 4. Pressing the [Enter] key then selects the option.

Menu [6] Unit Status

```
Unit ID =  <Master>
<Status>
Actual V= <      >
Actual I= <      >
```

This "display screen" allows the interrogation of the Master Unit or an individual Slave Unit to see what it is currently doing. Pressing the [Up] or [Down] key will navigate between the different discharger units, such that the status of all units in the system from the Master through Slave 0 to the last Slave Unit connected may be displayed.

The first line of the display will indicate the selected unit and when displaying a slave status the "data" light on the front of a selected slave will flash 3 times in rapid succession.

The "Status" field may show any of the following labels: Standby, Initialising, Discharging OK, Current Limited, Low Battery Voltage, High Battery Voltage, Over Temperature, Over Current, Mains Fault.

The "Actual V" and "Actual I" fields will display the voltage that the selected unit is seeing and the current it is discharging at. These values will only be a part of the total that is displayed in the menu [2] - Discharge Status display screen i.e. that part that the selected unit is contributing to the total system discharge capacity.

Menu [7] Unit Information

```
Unit ID =  <Master>
Serial #= <      >
S/w Version = <
>
```

This "display screen" allows the interrogation of the Master Unit or an individual Slave Unit in order to show some fixed information about it. The "Total Disch" field in the "display screen" shows the user the total accumulated hours that the selected unit has discharged for. The software version number and serial number of the unit are also displayed for reference purposes.

Pressing the [Up] or [Down] key will navigate between the different discharger units, such that the information for all units in the system from the Master through Slave 0 to the last Slave Unit connected may be displayed.

The first line of the display will indicate the selected unit and when displaying a slave status the "data" light on the front of a selected slave will flash 3 times in rapid succession.

Menu [8] Unit Rating

```
Unit ID =  <Master>
Rated DC V = <    >
Rated DC I = <  >x<
>
```

This "display screen" allows the interrogation of the Master Unit or an individual Slave Unit in order to see its rating. The "Rated DC I" field displays the current per module x the number of modules installed (i.e. a 48V / 6kW unit displays Rated DC I = 40 x 3). The "Available I" field shows the available discharge current capability of the unit, taking into consideration the number of DC circuit breakers currently switched on (i.e. a 48V / 6kW unit with only one circuit breaker switched on will display 40).

Pressing the [Up] or [Down] key will navigate between the different discharger units, such that the information for all units in the system from the Master through Slave 0 to the last Slave Unit connected may be displayed.

The first line of the display will indicate the selected unit and when displaying a slave status the "data" light on the front of a selected slave will flash 3 times in rapid succession.

Menu [9] Mains Configuration

```
Unit ID =  <Master>
Rated AC V = <    >
Rated  Freq  = <    >
# of  Phases= <    >
```

This "display screen" allows the interrogation of the Master Unit or an individual Slave Unit to see the rated AC mains configuration.

Pressing the [Up] or [Down] key will navigate between the different discharger units, such that the information for all units in the system from the Master through Slave 0 to the last Slave Unit connected may be displayed.

The first line of the display will indicate the selected unit and when displaying a slave status the "data" light on the front of a selected slave will fla sh 3 times in rapid succession .

Pressing the [Enter] key when the "display screen" is showing will switch the display to the "setup screen" this then allows the user to edit the "# Phases" field for the master or any of the Slave Units. A numerical value for the number of phases (1, 2, or 3) followed by the [Enter] key will set this field.

Stopping a Discharge

To manually stop a discharge, which c an be restarted again or completed, press the [Stop] key. This will halt the system discharge immediately. The discharge can be re-started if desired, optionally maintaining the totals for Amp-Hours and duration of discharge.

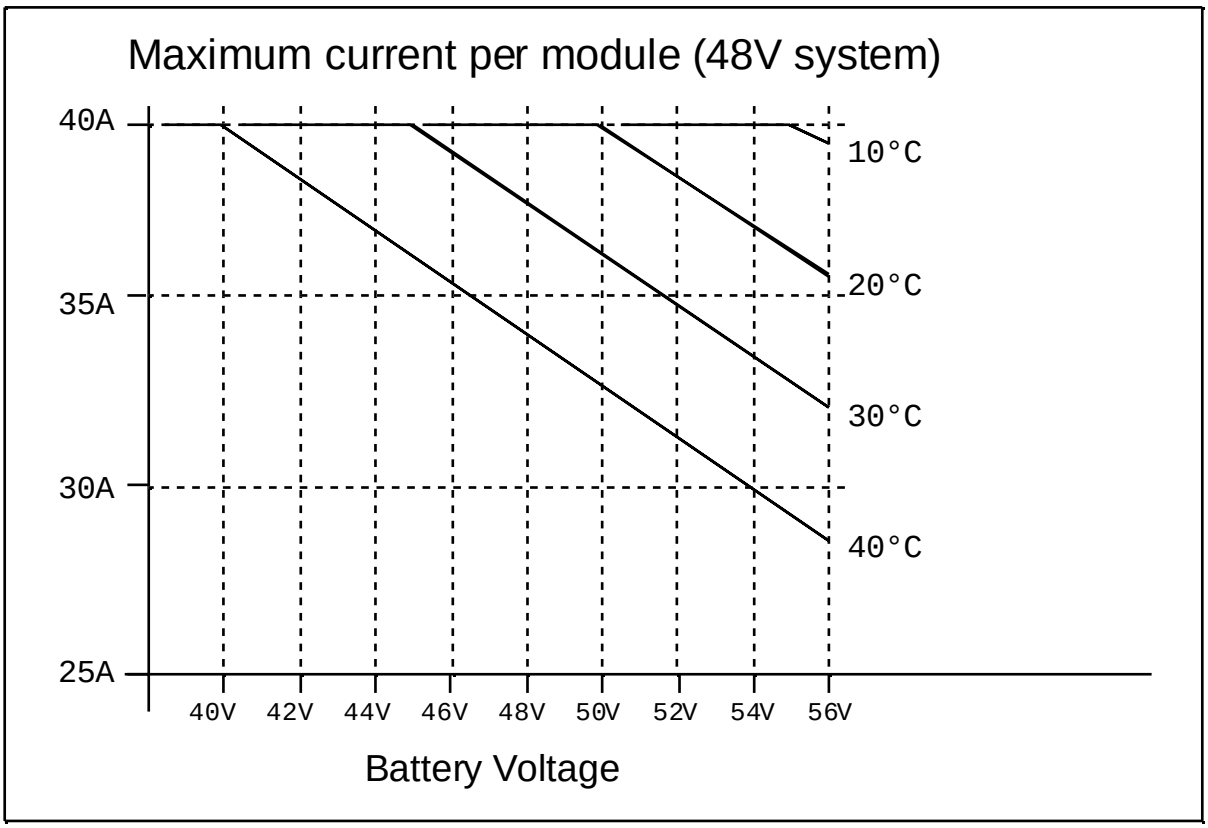
Note: it is important that the discharger is stopped before turning off AC circuit breakers - do not turn off AC circuit breakers during a discharge test.

Thermal De-rating

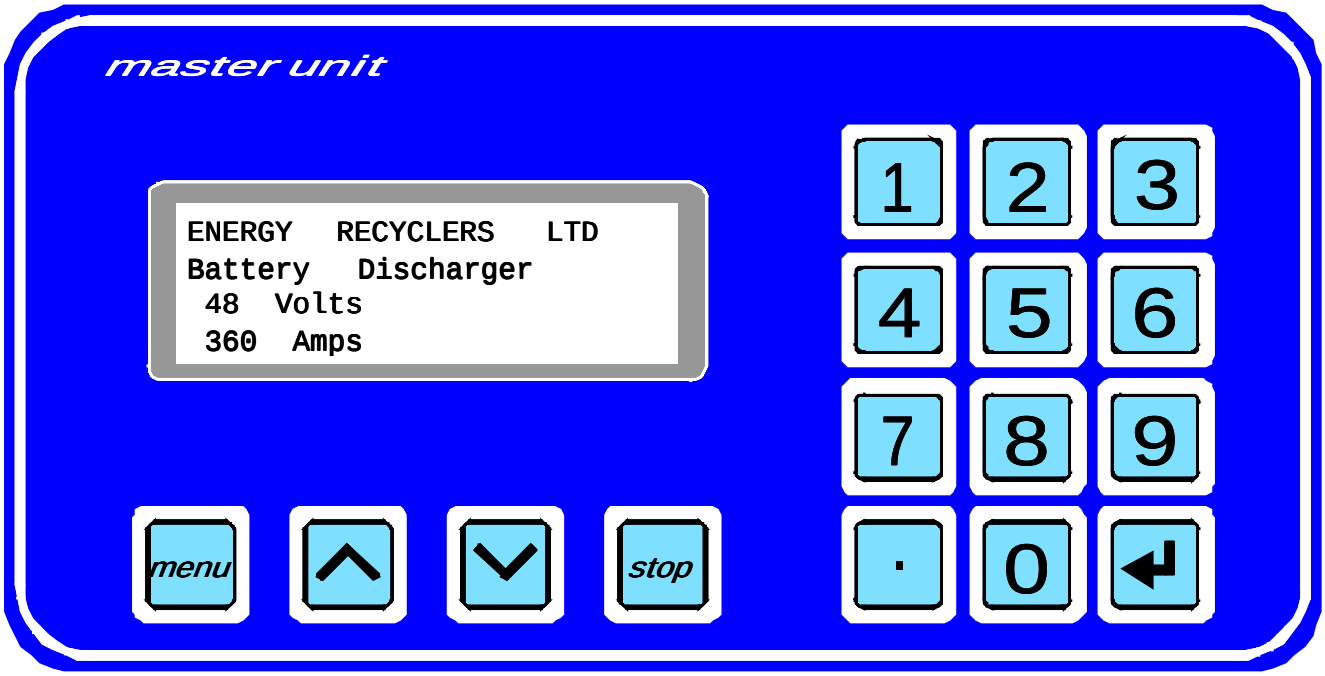
The discharger has a continuous input power rating of 2kW, 4kW or 6kW per unit at 20°C.
At the highest allowable DC battery voltage the power rating can be excee ded by 15% if full rated current is selected by the user.
As with all power electronic devices, operation of the discharger for prolonged periods at or near maximum capacity will result in high operating temperatures and accelerated deterioration of componentry . This will shorten the life of the product.
Each power module is fitted with a thermal temperature sensor which activates thermal shutdown if the module becomes too hot. To ensure that the thermal shutdown is not activated, do not exc eed the following discharge parameters:

Ambient temperature	Discharge Power (voltage x current)		
	1 module	2 modules	3 modules
-10°C	No limit	No limit	No limit
0 °C	No limit	No limit	No limit
10 °C	2.2kW	4.4kW	6.6kW
20 °C	2.0kW	4.0kW	6.0kW
30 °C	1.8kW	3.6kW	5.4kW
40 °C	1.6kW	3.2kW	4.8kW

- **Discharge Power can be calculated by multiplying the Discharge Current by the Battery Voltage (actual displayed voltage).**



Master Unit Keypad and Display



Typical System Configuration:

Depicted at right is a system comprising a Master Unit and four Slave Units.

Specification.

Master Unit:
48V / 120A (6kW)

Slave Units:
48V / 120A (6kW) x4

Cooling Modules:
5 x 1RU high vent ilators

Total System Capacity:
48V / 600A (30kW)

Discharge Capability:

i. One only DC circuit breaker on: 2A to 40A in 1A steps
ii. 40A to 300A range covered by changing number of DC circuit breakers turned on.
iii. All DC circuit breakers on: 300A to 600A in 1A steps

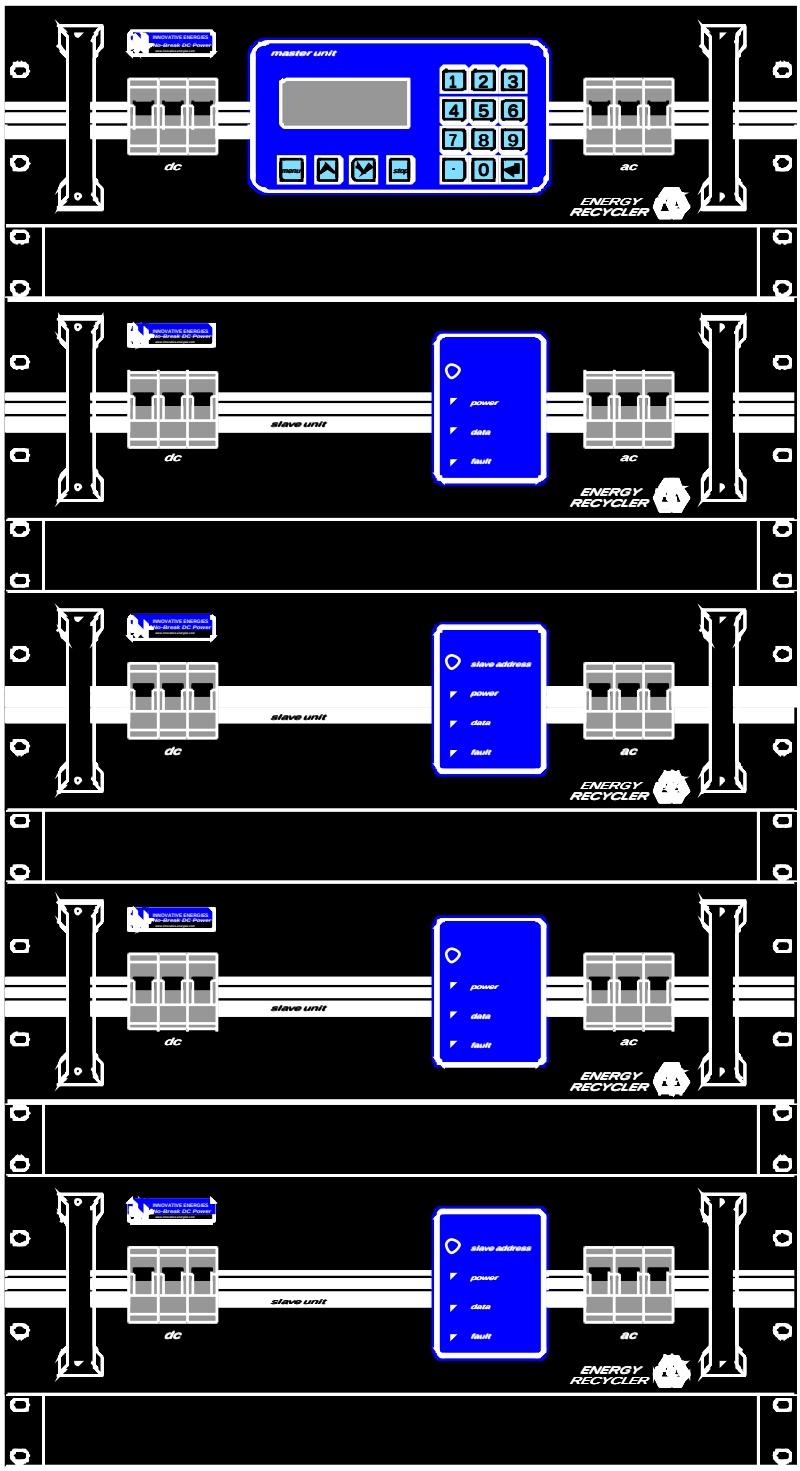
System Size:
19" W x 21U(934mm) H x 500mm D. This includes 1U above Master Unit (not shown) for cooling purposes

System Weight:
145 kg (approx)

AC connection:
3Ø 230VAC (phase to neutral), 4 wire + earth

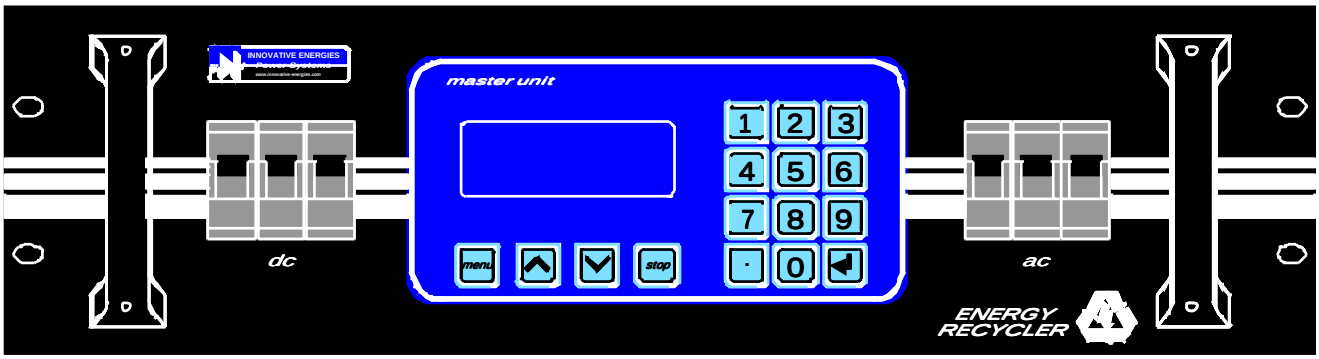
AC current:
Standby : +1A (Ø1 only)
Discharging: up to -40A per phase

Slave addresses :
0, 1, 2, 3

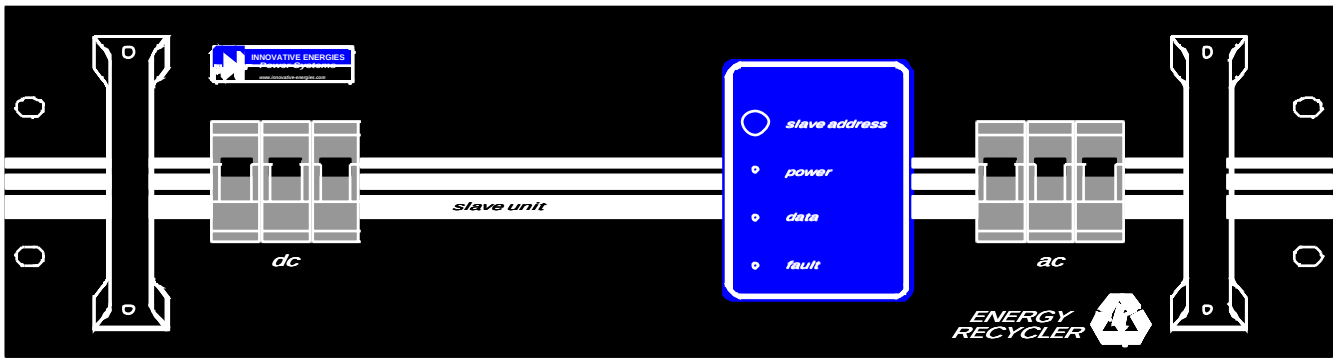


Front Panel Layouts

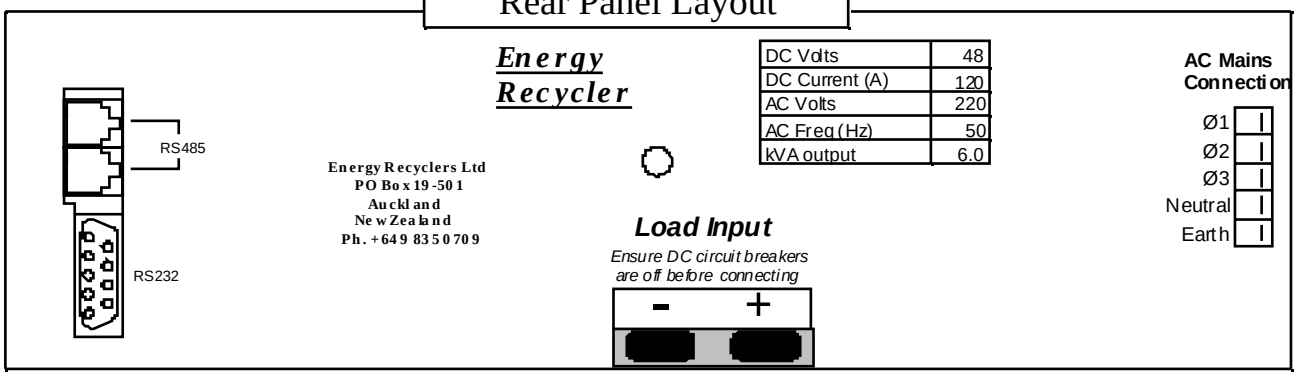
Master Unit



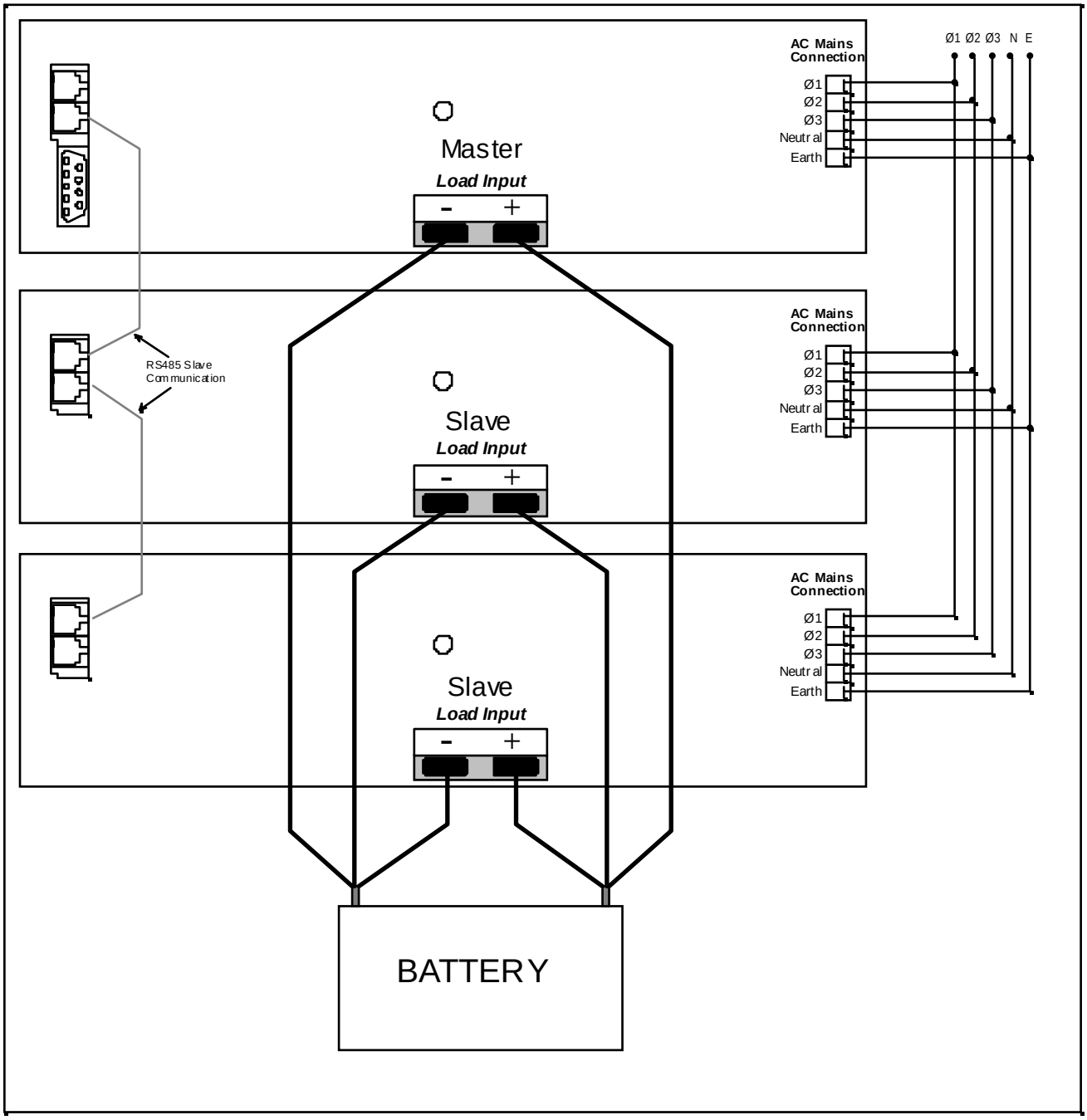
Slave Unit



Rating Label Information / Rear Panel Layout



Wiring Connection Diagram



Reinversion Dischargers Model Selection Table

	Master Units			Slave Units
24V input (18-29V) types Model #	**ER1500/24-M**	**ER3000/24-M**	**ER4500/24-M**	**ER4500/24-S**
48V input (36-57V) types Model #	**ER2000/48-M**	**ER4000/48-M**	**ER6000/48-M**	**ER6000/48-S**
110V input (82-131V) types Model #	**ER2000/110-M**	**ER4000/110-M**	**ER6000/110-M**	**ER6000/110-S**
# of Power Modules	1	2	3	3
Weight kg	17	23	29	29

Please specify when ordering:

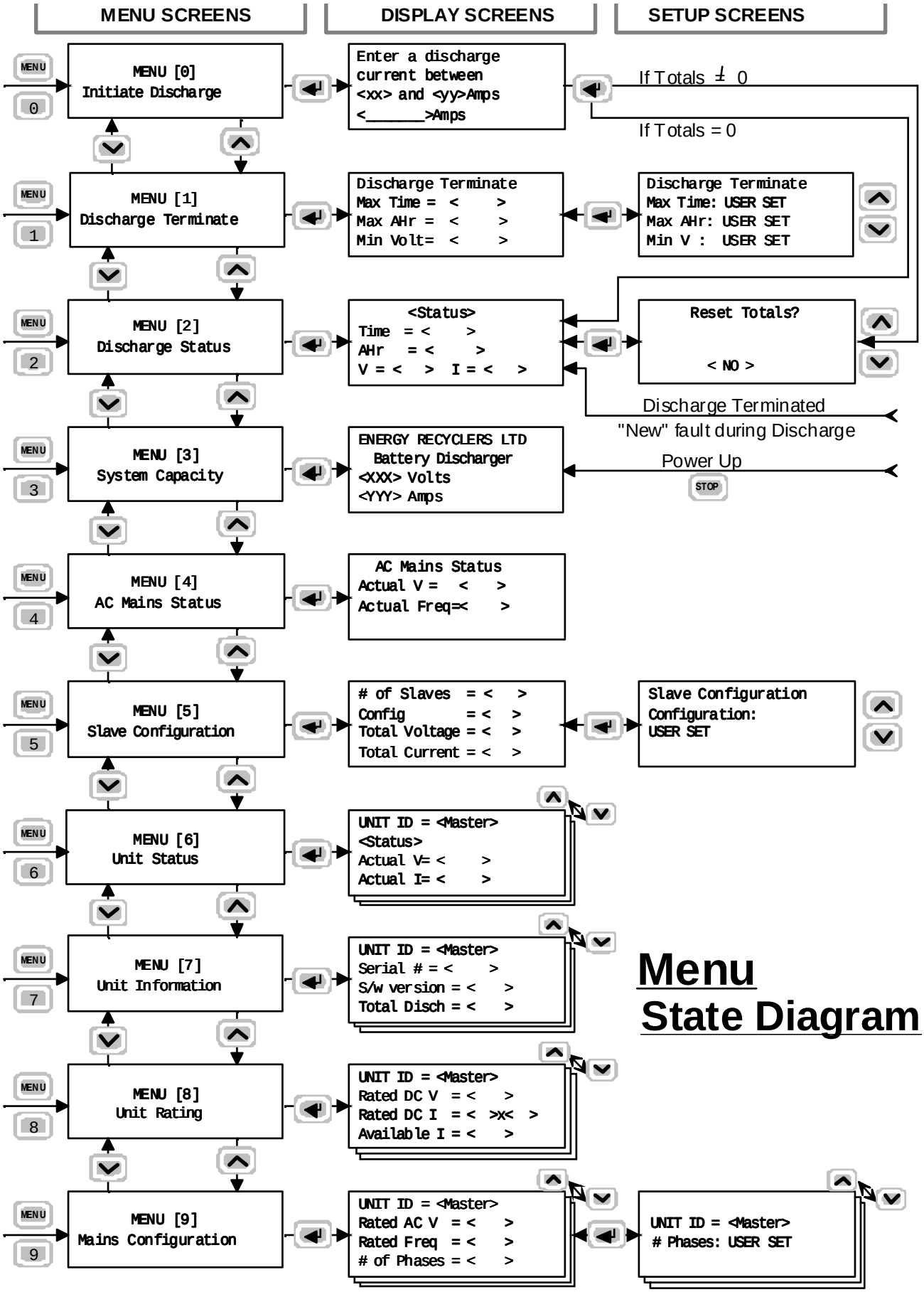
1. AC Mains voltage and frequency
2. Input DC voltage (nominal)

IMPORTANT SAFETY NOTICE.

Operational Precautions to be observed

The Reinversion Discharger has been designed for simple installation and operatio However, it is most important that simple precautions are taken to ensure troubl free operation:

- **Do not operate the product without first reading and understanding the User's Manual**
- **Ensure Safety Earth connection is made before operation (see User's Manual page 28)**
- **Do not remove unit cover. No user serviceable parts inside unit. Service by qualifie technical personnel only.**
- **Do not turn AC crcuit beakers off whilst unit is discharging: first press STOP button t terminate the discharge.**
- **Ensure unit rating is correct for the intended application: DC rated Voltage, AC rated Voltage, AC rated Frequency.**
- **Ensure DC Circuit Breaker(s) are OFF whilst connecting or disconnecting DC input plug.**
- **Ensure DC Battery Polarity is correct. REVERSE POLARITY CONNECTION WILL DAMAGE THE DISCHARGER.**
- **Ensure the discharger is adequately ventilated:**
  1. **Ventilator module (1U) installed beneath each unit**
  2. **Free space is provided above top rear vents**
  3. **No obstruction of any ventilation holes**
- **Ensure the rear of the discharger is adequately supported**



Menu State Diagram